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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

This number contains the complete account of the *Discussion* on ***"Some Aspects of the Design and use of Glassware in Relation to Natural and Artificial Illumination,"*** which took place at the last meeting of The Illuminating Engineering Society on March 21st, 1916.

Other Articles include :—

A SUGGESTED CODE ON FACTORY LIGHTING—THE LIGHTING OF A LARGE SHIPYARD OFFICE—LIGHTING OF THE WOOLWORTH BUILDING, NEW YORK, &c.

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EDITORIAL.

Illuminating Glassware.

The properties of glass, in the form of globes, shades and reflectors, window panes, lenses and mirrors, absorbing screens and coloured media, &c., fall naturally within the scope of the Illuminating Engineering Society, and the discussion on the subject at the last meeting of the Society on March 21st brought out many interesting points.

Since the outbreak of war we have come to recognise the dependence of this country on foreign manufacture for many essential glass articles especially those required for chemical and optical work. There have been similar difficulties in regard to illuminating glassware, such as the lack of satisfactory heat-resisting glass for globes and chimneys used with incandescent gas and oil lamps, electric arc lamps and other high tem-

perature sources. Some manufacturers have made considerable progress towards the supply of such articles but the difficulties, partly industrial and economic and partly scientific, must not be underrated, and it is evident that if the lost ground is to be regained a very complete study of the whole industry will have to be made.

While a detailed study of the industrial aspects of the problem hardly fall within our scope it is needful to remember that these considerations modify to a great extent many conclusions that might be reached on purely scientific grounds. Experience shows that in most sections of the glass industry there is no great difficulty in securing the proper materials. There is doubtless room for study of the correct composition of glass for various purposes and here the chemist can do excellent work. But when formulae have been obtained there remains the question of the practical working of the material and here the human element plays an essential part. While in some branches of glass manufacture proper appliances and machinery are the chief necessity, in others the skill of the individual operator is the determining element. In attacking new sections of the glass trade, therefore, the need of a supply of trained men for the time being imposes a limitation. It is also recognised that in most cases the cost of labour forms a very substantial part of the total cost of production; cheapness can therefore only be attained by producing on a large scale and the manufacturer is dependent to a very great extent on the expertness and goodwill of the operator.

A great deal has been said regarding the limitation of output and other labour difficulties. While there has doubtless been misguided action in this respect it is necessary to bear in mind the exacting nature of the work. The unsatisfactory conditions in some glassworks can only be remedied by a sympathetic consideration of the matter from the worker's standpoint and by educational measures which will both raise the skill of the worker to a higher level and enable him to get a clearer grasp of the factors on which the prosperity both of master and man ultimately depends.

We have touched upon the above matters in order to show that the regeneration of the glass industry is not a matter of scientific research alone, but of co-operative effort on the part of scientists and those actually engaged in the industry. The need for scientific method and research is, however, generally acknowledged and the discussion at the last meeting of the Illuminating Engineering Society on "Some Aspects of the Design and Use of Glassware in relation to Natural and Artificial Illumination," was very timely. The Society was privileged to hear the views of two members of the Glass Research Committee of the Institution of Chemistry. This Committee has already done most useful work in determining the composition of various kinds of glass required in chemical, laboratory, and other special work and there appear to be opportunities for useful work in the extension of these researches to include certain varieties of illuminating glassware.

There are many varieties of glass needed in the lighting industry which deserve further study such as heat-resisting glassware for globes, chimneys, &c., diffusing white glass for globes, shades and reflectors, and screens of standard absorbing power or of special colour such as are required for scientific work. The study of this question involves the devising of tests and definitions which will prescribe, with reasonable latitude, what the illuminating engineer requires ; and the examination, with the co-operation of manufacturers, of our existing facilities for the production of such glassware.

Another point, of great importance from the manufacturer's standpoint, is the possibility of effecting greater uniformity in commonly used glass articles. All must agree as to the desirability of avoiding forms of standardisation which would tend to restrict progress, or set bounds to the elasticity of design required to meet individual tastes. But there appear to be many kinds of widely used articles, such as plain globes, electric lamp-bulbs, &c., where the immense variations in the nature and dimensions appear to arise from caprice and the lack of effective co-operation rather than any condition in the industry. In such cases agreement on tentative uniform standards might be very beneficial both to users and manufacturers and proposals to this effect would doubtless be sympathetically considered by the large gas and electric supply companies, Government departments, and municipalities.

Regarded as a whole the glass industry certainly offers a field for useful inquiry. We do not underrate the difficulties of embarking upon new methods of manufacture and changing old established usage, but the present is surely the right time to take stock of the situation and see where we stand. On investigation it would probably be found that some kinds of glass are manufactured abroad for reasons which make it impracticable to do the same kind of work in this country. In other cases it might be found that existing difficulties could be overcome in course of time and with favourable results for the future. In other cases, again, it might be shown that although the prospect of making glass on a large scale was not very hopeful, yet the particular varieties under consideration were so essential in the national interest that it would be well worth while to establish a source of supply which could always be relied upon in time of need. Many of the varieties of optical glass, which have been so difficult to obtain since the outbreak of war, would fall within this category.

One thing at least seems to be well established—that the scientific study of the properties of glass has not received the attention that it deserves in this country, and it was this consideration which doubtless led Dr. Glazebrook, when presiding at a recent meeting at the Royal Society of Arts, to urge the necessity of establishing in London a central Optical Institute for the prosecution of such researches.

It has been agreed that the Illuminating Engineering Society shall appoint a Committee to consider the various problems raised in this discussion. The Committee will, we hope, be instrumental in bringing about co-operation in connection with this neglected subject of illuminating glassware and in initiating some useful researches.

Co-operation in Scientific Research.

In our last number we discussed the promotion of unity of effort on the part of the various bodies now engaged in studying the organisation of scientific and industrial research. This question was brought up at a recent meeting called by the Royal Society, at which many influential scientific and technical societies were represented. A Resolution was passed unanimously advocating the formation of a Conjoint Board of Scientific Societies with a view to promoting the co-operation of those interested in pure or applied science. It may be hoped that in due course the assistance of all the scientific and technical societies throughout the country will be secured, so that any question that arises may be allocated to the body which has made a special study of the subject to be considered.

There can be do doubt that some form of central organisation is needed. In many cases valuable work, deserving of being much more widely known, is being carried on ; yet such work may pass almost unnoticed outside the transactions of the Society concerned. The same applies to many Colleges and Institutions now engaged in Research work, and we notice that a letter on this subject has been contributed by Dr. A. E. Kennelly, of the Massachusetts Institute of Technology, to the Journal of the Franklin Institute (U.S.A.). Dr. Kennelly points out that there are many laboratories in the States working on independent lines, each, as a rule, conducting researches as though it were the only laboratory in the country, and therefore unaware of researches of a similar character that may be going on simultaneously at other Institutions. It would clearly be a gain if such laboratories could be co-ordinated without interfering with their individual initiative, and it is suggested that the Franklin Institute might take the lead in bringing about unity of effort. The Institute might, for example, give fuller publicity to the researches now being conducted, suggest subjects of research, offer grants to the laboratories best suited for them, invite suggestions from industries, and encourage mutual understanding between the laboratories.

In this country a similar state of affairs exists and it would be very helpful if some body could act in the way suggested above.

The question of organising suitable publicity for such researches should be studied by a central body in a position to determine when the results of research can be given freely to the public, and when their military or naval bearing, or their peculiar industrial value renders it necessary either to withhold such information or to present it in a very general form.

In any case it is clearly desirable that the existence of all such experiments should be recorded, in order to furnish a central source of information to which those who are entitled to receive details can gain access.

In cases where full publicity is desirable the co-operation of the scientific and technical press should be freely sought. Its value in this connection was pointed out in our last number when we referred to the discussion at the last meeting of the Circle of Scientific and Technical Journalists on March 14th, and it would clearly have a salutary influence if the various schemes for organising scientific research could be fully discussed by that body. The efforts being made in this direction by various associations should lead to useful results but it is most desirable that their aims should be widely known and discussed in order that any tendency to conflicting action and overlapping of effort may be recognised and avoided at an early stage.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME ASPECTS OF THE DESIGN AND USE OF GLASSWARE IN RELATION TO NATURAL AND ARTIFICIAL ILLUMINATION.

Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, London, at 5 p.m., on Tuesday, March 21st, 1916.

A Meeting of the Society took place as stated above, on Tuesday, March 21st, Mr. F. W. GOODENOUGH being in the Chair.

The Minutes of the last meeting having been taken as read the names of the following new applicants for membership were announced:—

Dobbins, Ed.	The Maximum Co., Ltd., 28 Victoria Street, LONDON, W.
Lancaster, E. W.	Holophane Ltd., 12, Carteret Street, Queen Anne's Gate, LONDON.

The Chairman then called upon Mr. S. B. LANGLANDS to read his paper, entitled, "Some Aspects of the Design and Use of Glassware in Relation to Natural and Artificial Illumination," and an interesting discussion took place, in which Mr. BERTRAM BLUNT, F.I.C., and Mr. W. C. HANCOCK, F.I.C. (members of the Glass Research Committee of the Institute of Chemistry), Mr. E. STROUD, Mr. A. P. TROTTER, Dr. M. W. TRAVERS, Mr. J. S. DOW, Mr. O. P. MACFARLANE, Mr. L. GASTER, Mr. W. M. MASON, Mr. R. W. HOOD, Mr. G. CAMPBELL, Mr. E. BARTON, and Mr. G. HERBERT took part.

Written communications from Mr. W. C. CLINTON, Messrs. STEVENS & WILLIAMS, Alderman R. BURTLES and Mr. ED. DOBBINS were also presented by the ASST. HON. SECRETARY.

Mr. S. B. LANGLANDS briefly replied, and a vote of thanks to the Author concluded the proceedings.

In conclusion, the CHAIRMAN announced that the **Annual Meeting** would take place at **5 p.m.,** on **Tuesday, May 9th.** After the conclusion of formal business there would be a discussion on the **Report** to be presented by the **Research Committee** of the Society.

SOME ASPECTS OF THE DESIGN AND USE OF GLASS WARE IN RELATION TO NATURAL AND ARTIFICIAL ILLUMINATION.

By S. B. LANGLANDS (Inspector of Lighting to the Corporation of Glasgow).

(Introduction to a Discussion at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, March 21st, 1916.)

MY object in these introductory remarks is to show the wide scope for study in relation to glassware for illuminating purposes, and to discuss a few of the problems that come within the scope of the Illuminating Engineering Society. At the present stage it is hardly possible to give much definite information as to what is being done. In the past, as is well known, we have been dependent to a very large extent on imported glassware. With the outbreak of war we came to realise more fully our dependent position, and steps are already being taken to improve our facilities in this respect. We are thus in a transition position. What I would like especially to bring home is that glass manufacture is essentially an industry which demands scientific treatment, and that the problems involved can only be effectually solved by co-operation between those interested in all the various uses of glassware for lighting.

I do not propose to enter deeply into the wider industrial problems, such as the attitude of the Trades Unions, the protection of home industries, &c., which are acutely illustrated in the glass industry. For the moment our duty is to study the scientific and technical aspects.

Being a material for the direction of rays of light, glass is naturally of interest to illuminating engineers who are concerned with the practical applications of light. Some of the members of the Society are interested in the design and use of optical instruments, and most of them come in contact with optical problems in which glass plays an important part. Last year a meeting of the Society was devoted to the discussion of searchlights, and in the past there have been discussions of globes and reflectors and of photometric instruments in which lenses and mirrors are used. The question of most immediate interest to us, however, is the use of glass in natural and artificial lighting.

For natural illumination the manufacture of prismatic glass for distributing the light in more or less obstructed interiors is of interest; even the manufacture of ordinary window glass, serving for the admission of daylight, has its problems. For artificial lighting we have the manufacture of electric lamp-bulbs, chimneys for gas and oil lamps, and globes and reflectors for all illuminants.

At the outbreak of war there were great inconveniences in this latter branch, particularly in respect of the so-called "heat-resisting" glassware. Much of the glass of this kind was made at Jena, and manufacturers in this country have already undertaken the production of glassware for use with high-pressure and other lamps, in which a considerable amount of heat is developed. Glassware for globes and chimneys has to fulfil a number of requirements. It must be (*a*) suitable transparent, (*b*) colourless, (*c*) capable of withstanding heat, and (*d*) must be durable and must retain its transparency in use.

Some years ago I made rigid practical tests of different varieties of glass for a certain burner, with the following results :—

(A) A German glass.—First for durability, but bad for fogging.

(B) A German glass.—Second for durability, and better as regards fogging.

(C) Jena glass.—Third for durability but no fogging.

(D) British glass.—Fourth for durability, unequal in composition; sometimes fogged and sometimes did not.

(E) American glass.—Fifth for durability. No fogging.

I mention this test because it showed a weakness in the British glass, lack of uniformity which is essentially a defect that implies want of scientific supervision. The remarkable success of the Jena works,* State-aided in their infancy, is doubtless due largely to the consistency of the material supplied, the ability to manufacture a glass with given chemical and physical properties again and again. Fogging is ascribed to the presence of lead in the glass. Jena glass contains no lead. It is a fact that since the war began a number of British glass works have undertaken the manufacture of improved glass in this respect. But if this progress is to continue it is essential that the qualities and composition of glass should become standardised on scientific lines, thus forming a groundwork on which we can build for the future.

In addition to the question of standardisation of material, there seems an opening for standardisation in regard to dimensions of glass implements.

Those who have had to do with the lighting of large numbers of buildings know how inconvenient and unnecessary are the great diversities in the size of lamp-bulbs, chimneys, globes, &c. As one who has to do both with gas and electric lighting on a large scale—Glasgow is, perhaps, the biggest lighting authority in the Kingdom—I have often been struck by this fact, and I would suggest that this Society, representing so many sections of the lighting industry, is in a particularly happy position to tackle the problem. Standardisation in this respect would not only simplify greatly the manufacture of glassware for lighting purposes, but would also prove a convenience to consumers. If possible the variety of sizes of glassware should be diminished, and a definite series of units in ascending units agreed upon. The sizes selected for globes would naturally depend to a great extent on the candle-power of the lamps for which they are intended. In the case of globes for softening and diminishing the light the size would depend on the limitation of temperature and the maintenance of the intrinsic brilliancy of the unit within a convenient value. Probably it would also be affected by aesthetic considerations as the size of a unit should presumably bear some relation to the size of the interior in which it is used.

Another point on which information would be of interest is the success with which makers in this country have undertaken the production of pressed glass globes in the larger sizes. I understand that the Holophane prismatic glassware was established in this country previous to the war, but it is common knowledge that many of the large white glass units of a decorative kind were imported from abroad, and it is surely up to us to produce good work of this kind in this country.

The question of standardisation of material applies also to hemispheres and globes of a diffusing kind. It is well known that the qualities of white glass available differ very much. In some cases, flashed opal for example, uniform illumination over the entire surface is readily obtained and the filament or mantle is entirely obscured; in other cases, pot opal for example, one can still see the source through the glass and the diffusion is not so good. It is therefore of interest, from the lighting standpoint, to specify exactly the quality of the glass so as to secure the requisite uniformity of diffusion, combined with minimum absorption.

Similarly, the colour and permanence of such glasses need to be specified. One finds that some varieties of so-called white glass are apt to become tinged with yellow, and that sometimes an uneven density is produced. Such defects will not be found in the finest glassware. Again, in the case of the larger units the *weight* of the glass is not without significance. In view of the tendency towards the production of sources of high candle-power, this element may have an appreciable effect on the question of fixture-design.

* I would refer those interested to the work by Hovestadt on "Jena Glass: Scientific and Industrial Application." Translated by J. D. and A. Everett.

The need for standard dimensions is equally important in the case of reflectors. It is particularly important to check, as far as possible, the tendency on the part of the public to use lamps with reflectors for which they are totally unsuited. Many of the existing reflectors designed originally for carbon filament lamps, for example, are quite unsuited to the metal filament lamps and still more the "half-watt" lamps.

Another matter requiring the supervision of the Illuminating Engineering Society is the testing of the absorption of glasses and of globes and reflectors composed of various kinds of glass. One finds that there are great differences of opinion regarding the amount of light absorbed by different kinds of glassware, and the uncertainty on this point is intensified by the fact that it is possible to get two varieties of glass which appear very similar to the eye but differ widely in respect of absorption. This again, is particularly true of white glass the constitution of which is conveniently analysed under the microscope. In this way differences in quality may be revealed which would escape the naked eye, and differences in diffusing power may be explained.

In regard to reflectors the "reflecting power" is still further complicated by the differences in the percentage of the total light-flux enclosed by the reflector. Obviously a very shallow reflector, which only intercepts a very small portion of the rays of light, would have an apparently high reflecting power; but, nevertheless, it might entirely fail to comply with the requirements of a good reflector as regards screening the light source from the eye and promoting the proper distribution of light. It would appear, therefore, that when mentioning the amount of light reflected by a unit, some statement as to the percentage of the light flux enclosed is also called for.

Tests of the absorbing power of globes and reflectors immediately introduce photometric problems, and call for the services of the illuminating engineer. The preparation of a series of samples of typical glass accompanied by data as regards composition, colour, and absorbing power would be of great value. In regard to fancy coloured shades, the testing of colour is of some importance, and even more so in the case of coloured glasses manufactured for certain specific purposes (*e.g.*, for signal glasses). Accurate tests of such glass require the use of the spectrophotometer, and there are other means, which have been discussed before the Society, of studying such problems. It appears, however, that there is a need for some very simple form of colour-analysing apparatus, and the Society, which has done so much to simplify measurements of the intensity of illumination, might also devote its efforts towards the production of simple instruments for colour-analysis.

Such investigations are also of importance in studying the want of permanence in the colour of glasses and the explanation of fading.

An allied problem for the Society to consider is the production of glasses excluding rays of light which are deleterious for certain classes of work. There has been much discussion of recent years regarding the influence of the ultra-violet rays on eyesight. Whatever be their influence in this respect, it seems to be well established that such rays have a considerable effect in causing the fading of colours of pictures and fabrics. I believe that a glass has been produced in this country capable of absorbing such rays, and therefore suitable for use in glass cases intended to contain valuable coloured objects for exhibition. This point is of special interest to lighting engineers because of the discussion that has taken place regarding the effect of artificial light on coloured materials. There seems good ground for thinking that, however artificial illuminants may differ in this respect, the majority of illuminants, as used for ordinary purposes of illumination, are much less likely to cause fading than prolonged exposure to daylight. But in special cases it might be desirable to include lamps in globes made of a variety of glass which checks the ultra-violet rays but allows the visible rays to pass unimpeded.

Yet another interesting problem is the production of tinted glass for use with artificial illuminants to produce "artificial daylight." Bulbs for incandescent electric lamps have recently been made of such material, and screens for use with

incandescent gaslight have also been developed. The problem is of considerable interest to industries where correct colour-matching is essential, and it would be very desirable to have glass for this purpose accurately analysed and specified for different types of lamps.

Finally there are many problems that arise in connection with the making of optical instruments which are also of importance in photometry; and conversely there are many optical problems in which convenient methods of measuring light are of great assistance. Experts on photometry could often furnish a hint to those engaged in optical problems. One question which has doubtless often forced itself before the notice of photometric workers is the production of neutral glass of standard absorbing power. There has been no difficulty in obtaining from abroad neutral glass plates transmitting exactly 10 per cent. of the light; but it has hitherto been a very difficult matter to get similar glass in this country.

The advance in Germany in this respect, as well as in many other special lines of optical research, can be traced to the evolution of the Jena works. In the first instance the scientific work undertaken at Jena was not directly remunerative. But the Government had the foresight to see that it had great future possibilities, and that the ability to manufacture accurate standard glass for all sorts of purposes would create a need for it. History has proved the correctness of this view. On the research work at Jena many subsidiary optical industries have been built up. Similarly, the fine glass works in Austria have been slowly developed through many years of scientific research.

Since the war broke out many manufacturers in this country have made praiseworthy efforts to fill the gap, and in many cases substantial progress has been made. Yet, taken as a whole, such efforts are apt to be unrelated and chaotic. There is a need for the co-ordination of all such individual efforts by some form of central control, and if progress is to be lasting and progressive the industry must be organised on scientific lines. Even so we cannot expect rapid progress, for time will be needed before the influence of scientific study begins to tell.

In particular it is desirable that the scientific sections of the work and the standardisation of material should be guided on some co-ordinated plan. The Institute of Chemistry of Great Britain and Ireland has already done excellent work in devising formulæ for glass required for various purposes.* It is to be hoped that for lighting purposes glassware will also be the subject of careful study. In the National Physical Laboratory we have a scientific institution which is already doing good work, and which only requires greater support to be of immense benefit to the glass industry. It has also been suggested that the scheme for a Central Institute on Applied Optics, suggested before the war, should be carried through. In such work the various scientific associations and societies throughout the country should play a part, and there are signs that the Government is willing to consider taking a more active part in fostering the industry. From personal experience I can say that the Board of Trade have already done a good deal considering their present powers. Similarly, I notice that the Board of Education has been considering the establishment of better educational facilities for instruction in glass-blowing and similar processes involved in the manufacture of scientific instruments.

In undertaking such work the authorities will have to consider both the scientific requirements of the industry and the industrial problems which I have briefly mentioned above. The problem is a difficult one but a highly scientific industry like this is well worth the effort involved as it reacts on so many other trades and professions.

In conclusion, I would like to recall for discussion several definite proposals made in the course of this address:—

(1) There is a need for standardisation in respect of materials used in various kinds of glassware used in the lighting industry. It would be very desirable for a complete series of samples to be prepared, attached to each being par-

* Particulars of some of the varieties of glass so far investigated are given in the Appendix (p. 122).

ticulars of the chemical composition, absorbing and diffusing qualities, colour, permanence and durability, and special applications.

(2) An effort should be made to standardise the dimensions of glassware used for lighting purposes, the shapes and sizes of globes and reflectors being limited to a convenient prescribed series.

(3) The conditions of testing the reflecting power and other qualities from a lighting standpoint of globes and reflectors should be more precisely formulated.

(4) An effort should be made to simplify and standardise the apparatus for testing different varieties of glass as regards colour.

(5) The Illuminating Engineering Society should co-operate with other bodies in forming a Committee to consider these problems.

APPENDIX I.

Some Notes on the Preliminary Report of the Glass Research Committee of the Institute of Chemistry of Great Britain and Ireland.

In the Preliminary Report of the Glass Research Committee it is mentioned that research has been conducted on the following glasses and formulæ specifying their compositions have been determined :—

1. and 2. Soft glasses suitable for ordinary chemical laboratory ware, which do not give up alkali readily to water, work well in the blowpipe and do not devitrify readily.

3. Resistant glass suitable for pharmaceutical purposes, ampoules, &c., intermediate in hardness between soft glass and combustion tubing, and highly resistant to chemical action.

4. and 5. Glasses for combustion tubing, closely resembling Jena combustion tubing, and having practically the same fusing point.

6. and 7. Miners' glasses, colourless and fusible and capable of withstanding rapid changes of temperature.

8. Resistance glass, almost identical in its general behaviour with Jena resistance glass.

9. An alternative glass for combustion tubing.

10. 11. and 12. Soft glasses suitable for tubing and for X-ray bulbs.

13. Glass for ordinary chemical laboratory ware, alternative to No. 1.

14. Glass for tubing, X-ray bulbs, &c., alternative to No. 10.

Since the publication of the above formulæ, some further information on Glass Research has been issued in the Proceedings of the Institute (Part I, 1916). The Glass Research Committee have lately forwarded to the Advisory Council on Scientific and Industrial Research reports on formulæ for :—

15. Blue Enamel for sealing metallic wire into glass.
16. Lead Glass suitable for electric light bulbs.
17. Lead Glass similar to above, but avoiding potassium carbonate.
18. Opal glass designed to join perfectly with glass made to the Committee's formulæ Nos. 1 and 10.
19. High temperature thermometer glass.
20. A leadless opal glass which unites with No. 19 and can be worked with it as an enamel backing for thermometers, &c.
21. Thermometer glass for ordinary temperatures.

It is added :—

"The fact that these formulæ are available has been reported to British glass makers, from whom a large number of applications have been received and are now under the consideration of the authorities."

"With regard to research on optical glass, the Advisory Council have asked that the Glass Research Committee shall keep in touch with the National Physical Laboratory, to which a grant has also been allotted. The primary object of the work of the Laboratory will be 'the study of the process and condition of melting and producing glass of good optical quality with special reference to refractories and electric furnaces methods, with a view to putting the whole process of manufacture on a practical scientific basis.'"

"The line of investigation undertaken by the Glass Research Committee of the Institute is the study of certain optical glasses urgently required for industrial purposes, with a view to their early production by manufacturers."

DISCUSSION.

The CHAIRMAN said that the subject of the paper was one of pressing interest at the present time, and called for scientific research and scientific treatment. From an industrial standpoint the problem was also a serious one, and there were conditions which stood very much in the way of the scientific and commercial development of glass manufacture in this country. It might be hoped that these difficulties, which, however, must be discussed on another platform, would be overcome in course of time.

He was glad to see that Mr. Langlands had said a good word for the Board of Trade, because it was also his experience that during the war the Board of Trade had done all that could be done to help in many ways, considering the limited means at its disposal.

Mr. BERTRAM BLOUNT, as a member of the Glass Research Committee of the Institute of Chemistry, mentioned in the paper, said he believed that Committee had done splendid work, resulting in something practical. He also supported the Author and the Chairman in recognising the extreme help which the Board of Trade had given in the matter. The main difficulties in the case of the glass industry had been Treasury difficulties, but by a plain statement and not by persuasion the Institute of Chemistry Committee had obtained the necessary monetary help which had enabled a research to be carried out for a few hundred pounds, which he believed would bring our industries into a state of great prosperity.

Mr. W. C. HANCOCK, also a member of the Glass Research Committee of the Institute of Chemistry, said that a number of glass manufacturers had actually undertaken to manufacture glass according to the formulae which had been provided. Some of them had encountered difficulties, and had asked the Committee for further help and advice which had been willingly given.

The work carried out by Prof. Jackson for this Committee at King's College had been simply tremendous, for he had not confined himself merely to the carrying out of experiments for the elucidation of the formulae, but had given most valuable help to the manufacturers. With regard to glass capable of excluding ultraviolet rays, Sir William Crookes had done a good deal of valuable work a few years ago in this connection which should be capable of useful application now. The work of the Committee of the Institute of Chemistry had resulted in several steps forward being taken, especially when the extreme shortage of glass for steel works laboratories and for miners' lamps at the beginning of the war was realised. A difficulty at first, however, was the necessity for skilled workmen, but this to a large extent had been overcome. Mr. Langland's scheme was extremely ambitious and should be undertaken thoroughly so that all interests concerned could be co-ordinated. He certainly hoped that the manufacturers would come forward and take their part in the whole scheme, because it was useless to attempt to patch up the industry in parts. There were possibilities for the glass industry in this country being made an extremely remunerative business, and the manner in which optical glass had been tackled by the Institute of Chemistry, and also by the National Physical Laboratory, showed that we had the means at our disposal for avoiding that dependence upon foreign sources which existed before the war. Such a state of things ought never to have been allowed to arise, and he hoped it would never recur.

MR. E. STROUD: The paper by Mr. Langlands, although comparatively short, opens up such a variety of questions in regard to glassware for lighting purposes, that one can only analyse and deal with a few of the chief suggestions in the time available.

The war has certainly brought home to us the extent to which we were dependent on abroad for many forms of glass, especially glass of a heat-resisting character. In my own experience, in connection with Holophane glass, these difficulties have not arisen, since glass-

ware of this kind is manufactured in this country.

In this connection Mr. Langland's remarks are of great interest, because the utility of Holophane glassware is very greatly wrapped up with precision in manufacture and standardisation, as regards composition and form of mould. Any form of glassware which is stated to give certain illumination values with a certain type of lamp must, of course, be accurately manufactured, and the moulds used for Holophane glass have to be made with the greatest care: in the larger sizes the number of calculated faces may amount to many hundreds, and the correct reflection of the rays depends on the angle of the prisms being exact and the surface of the glass highly finished.

Seeing that we deal with transparent glass we have the advantage of extremely low absorption values.

The variation in distribution is achieved by shaping the prisms, and we have only to produce consistently glass of uniform colourless transparent quality. It is of course vital that any tendency to yellow colouration should be avoided, and we find that with our reflectors the colour of the light from any form of lamp is not affected, as it might be by cloudy media.

As regards the question of heat resisting power, we have adapted Holophane reflectors very widely for gas, and find no difficulty in obtaining units which do not crack or discolour with the heat; I should like to point out that in our experience success in this respect is often as much a matter of correct design of unit, provision for ventilation, and expansion of glass and gallery as quality of glass.

The question of standardisation, as suggested by Mr. Langlands, is a very important one. If by "standardisation" he means exact reproduceability in the quality and dimensions of units, we can claim to have done pioneering work in this direction. If, however, it is implied that the units supplied by different manufacturers are to conform to a given range of dimensions, this is a much larger proposition. The first step in this direction should clearly be taken by the makers of lamps and burners, to whose requirements manufacturers of reflectors must, to a great extent, conform. As was suggested at a recent meeting of this Society, a more complete understanding as to standard sizes of bulbs and positions of filaments therein would be a great advantage, as the results obtained from any reflector are naturally dependent on these factors; however accurate we may be in standardising the reflector, the illumination obtained will vary if the position of the filament within it alters greatly according to the type of lamp used.

I fully agree with the remarks of the author regarding the need for greater precision on defining the "reflecting power" of various units, and the amount of light absorbed. There is a great deal of misapprehension on this point, and the question should always be considered in conjunction with the general qualities of the unit. Some units have a low absorption value, merely because they do very little reflecting, and there ought to be a standard practice in testing the absorption and other properties of glasses.

The question of selecting certain sizes of units to fall within a predetermined intrinsic brilliancy is also a somewhat difficult one; naturally in designing Holophane units we have kept this matter in mind, but it is obvious that much depends on the position occupied by the lighting unit. In other words, the supply of the lighting unit must go hand in hand with a knowledge of how it should be applied in practice. This has always been our practice, and we fully recognise the need for precision in manufacture in order that predeterminations of illumination may be carried out in the actual installation.

Mr. A. P. TROTTER said the question of glass was a very wide one and was divided into various branches, which had very little to do with each other. There was the question of optical glass, chemical glass, and glass for lighting purposes. This latter included shades, globes, chimneys and so forth, and in the case of gas shades, heat difficulties were encountered. Then there was another important section, the so-called opal glass which he regarded as a convenient term covering a large number of different kinds of diffusing glass. It was very desirable that the buyer of glass or of glassware should know definitely what

he wanted, that he should be able to describe it in accurate terms, and that the dealer or manufacturer should be able to understand the description and to know whether he was able to supply the goods. In 1882, when he brought out his dioptric shades, which were the forerunner of the Holophane system, he had great difficulty in finding any manufacturer who could undertake to make them. In discussing the matter with a well-known firm he asked the manager, "What is the refractive index of your flint glass?" "What index?" "Refractive index." "Oh, we have nothing of the kind!" The Americans were far ahead of us in this matter of opal glass or milk glass as it is sometimes called, and had magnificent laboratories in which researches were carried out by men who gave their whole attention to the technology of the subject of glassware. The subject was encumbered at present with a number of trade names; some of these referred to combinations of opal and ground glass. Flashed opal consisted of a thin layer of densely turbid glass spread over a sheet of transparent glass. Some kinds of opal glass had very poor mechanical qualities, and the clear glass acted as a support. Most glasses of this kind showed the lamp behind of reddish colour (and which could easily be explained optically) and that was surrounded by a diffused light. This differed from ground glass, where one saw a large patch of light surrounded by a dimmer patch, which could also be explained optically. The Americans had succeeded in producing a dilute mixture of the diffusing material with clear glass, and had produced rather clumsy shades, very thick and heavy, but with peculiar scattering characteristics. Volume 10 (p. 353, *et seq.*) of the Proceedings of the American Illuminating Engineering Society contained a good deal about diffusive reflection and transmission, but the theoretical part was too mathematical and theoretical and the experimental results were of little or no practical use to manufacturers.

He himself began some years ago an investigation of the scientific aspect of the scattering of opalescent or general translucent substances, and of the analogous subject of the scattering of a white reflector, but it required a great deal of experiment, and he could only do this in his spare time, and at present he saw no chance of going on with it. The behaviour of translucent substances differed a good deal, as everyone knew from the grease spot on the Bunsen disc, where a change in the direction of view showed that the law of scattering of the paper was not the same as the law of scattering of the wax.

There was some difficulty in dealing with the author's conclusions. In the first, dealing with standardisation of materials, he asked for samples. While it would be a good thing to have samples so that one would be reasonably sure of getting something near what was ordered, he did not see how manufacturers could be asked for the chemical composition of their glass. As to standardising dimensions of glassware, that in itself was good, but the author suggested it should be limited to a convenient prescribed series. Personally, he thought there had been too much standardisation, in certain branches of electrical and other engineering, and he would hesitate about adopting restrictions which would limit choice of sizes. As to the third conclusion, that was a highly scientific matter and had already received a large amount of attention from the Society. It would be rather difficult to standardise, although it would be well to know that a reflector, for which certain powers were claimed, had been intelligently tested. As to standardising a testing apparatus for glass as regards colour, that had been very largely done scientifically and by the spectro-photometer, as well as by other methods which were practically effective up to a certain point, but entirely unscientific, such as that adopted by Mr. Lovibond. The question of artificial daylight had been gone into some time ago by the Society, and he had shown an instrument for testing lamps of that kind. Daylight lamps at that time were very poor, but the Americans had since gone ahead very rapidly. His own apparatus was now in the hands of a manufacturer, who, however, found it perfectly impossible to touch it on account of the war.

Dr. M. W. TRAVERS said that Jena resistance glass, and the glass from which

Duroglass, Ltd., manufactured chemical glassware and gas globes, were practically the same thing. The selection of a glass for these purposes was always a matter of compromise, for while one kind of glass was very highly "heat resisting," another kind was more inactive towards chemical reagents, and did not "fog" when exposed to combustion products of gas. While, for instance, "Monopel" glass was more highly heat-resisting than Jena glass, it fogged more readily. This appeared to be due to the presence of lead and antimony in the former. His firm preferred to manufacture a glass free from these heavy metals, which they entirely excluded from their works, as they were objectionable as impurities in chemical glass. If they were to undertake the manufacture of gas globes on a larger scale it would be necessary to consider the matter further, and to work out a glass most suitable for this particular purpose. With regard to standardisation, he had to point out that we had not really advanced very far in our knowledge of glass, and its manufacture, in this country, and that standardisation, might mean sterilisation. This applied even more to methods of manufacture than to varieties of glass, for given any one kind of glass there would probably be at least "nine and fifty ways" of producing it, and both formalæ and works practice could be varied considerably. The manufacturer would, however, like to see an attempt at standardising patterns and sizes, the variety of which appeared to be unlimited.

Mr. J. S. Dow said that since the war began a number of glass makers had been making independent efforts to produce the so-called "heat-resisting glass" for use with high pressure gas lamps, &c., and no doubt some measure of success had been already obtained. But from what he had heard it appeared that there were considerable variations in the quality of glass sold under this title; in some cases the glass was quite good, in others very far from justifying comparison with Jena glass. He had had an opportunity of seeing at the Institute of Chemistry some of the samples of laboratory glass of various kinds, on which the Research Committee of the Institute had already done such good work, and had been particularly interested in the specimens of combustion tubing. The formula for this glass was known, and it seemed possible that, with a little modification, this work would also have an application to heat resisting glass required for use in the lighting industry.

Mr. Langlands and Mr. Trotter had both referred to the need for standardising the qualities of opal glasses. There is little doubt that the globes and reflectors of this type in use at the present moment are very unequal, some being satisfactory but others unsatisfactory in colour, uniformity and diffusing effect.

Similarly the question of preparing coloured glass screens for the production of "artificial daylight" needs attention. Screens of this kind have been described at several meetings of this Society. They have been prepared for use with incandescent electric lamps (of which bulbs of special daylight glass have also been blown), for incandescent mantles and for arc lamps. No doubt they would also be very readily applicable to the half-watt lamps. This question of producing convenient small artificial daylight units is of considerable proportion importance in the dyeing and textile industries and in other work where accurate colour matching is involved. In this case scientific precision and accurate reproduction of glass is essential. It is not desirable that there should be a great variety of glasses all claiming to give artificial daylight with a particular illuminant, but all departing from it to a greater or less extent. It should be possible to ascertain scientifically with the spectro-photometer how near to average daylight we can get with different illuminants, and the glass required in each case should be accurately specified so that it can be reproduced by any glass manufacturer. The solution of this problem demands the combined work of the photometric expert, the chemist and the glass manufacturer. The Illuminating Engineering Society might with advantage approach the Institute of Chemistry and the National Physical Laboratory on this matter.

Another problem of importance not only to photometric workers, but to all who have to do with optical instruments, is

the production of standard neutral-tinted glass. Such glass is an essential product in many scientific experiments in optics; yet, before the war, it was impossible to purchase in this country plates of neutral glass guaranteed to absorb a certain percentage of light—although a series of such glass has been produced at Jena and has long been listed by glass makers and scientific instrument manufacturers in Germany

Mr. Dow added that he had had personal experience on this matter when endeavouring to get dark glasses respectively transmitting 10 and 1 per cent. of the light for the Lumeter photometer. Such glasses are essential in order to get a really wide range, for example to measure up to 1000 ft.-candles or more. Although he had the advantage of the advice of Mr. Conrad Beck, they were unable to get any standard neutral glass in this country and eventually they had to pick out some sheets by inspection, and afterwards cut them down and find out by trial and error the required thickness. Even then the glass was not strictly neutral and it was found necessary to combine two samples (one too red and one too green) in the form of a wedge in order to make a suitable screen.

These instances, Mr. Dow concluded, showed the need for standardisation. Naturally glass makers would always have their individual preferences and differences in method. But it seemed highly desirable that there should be some central source from which definite information on standard glasses of the kind indicated above could be obtained, so that our knowledge on such matters could be permanently placed on record. In this way people would know that there was in existence at least one complete series of formulae for glass of every description, to which recourse could be had in any difficulty. The Institute of Chemistry appeared to have already made an excellent beginning in this respect.

Mr. O. P. MACFARLANE spoke on the question of glass required to withstand the intense heat produced by incandescent oil lamps. In this connection "Monopel" was certainly a very fine glass, but was exceeded in its heat-resisting power by another glass coming from Prussia known as "Resisto." Jena glass was not of first-rate quality as regards heat resistance, but was very good with regard to absence of fogging.

He would like to encourage glass-makers in this country in the production of heat-resisting glass because it should be a very lucrative business. It would require very careful manipulation, because the quality and the uniform thickness was all-important. Samples of British-made globes which recently came into his hands were as irregular as the waves of the sea, and their production was remarkable. Inequalities in thickness were almost fatal to a glass required for heat resisting purposes. He thought that one of the greatest weaknesses at present was the lack of skilled workmen. It was perfectly wonderful to see the regularity and precision with which glass was produced on the Continent. Americans had endeavoured to supply this country with this glass, but the results had been very disappointing. In appearance the American glass approached very closely to the German, but it had not got the same heat-resisting quality, notwithstanding that German workmen had been taken into American factories. Apparently they had not obtained the cream of the workmen.

MR. L. GASTER said he quite concurred in the view that it is not necessary to have so many different globes, bulbs, and chimneys, differing not only in the nature of the glass but the dimensions as well. Naturally globes and shades would have to be of different qualities according to the purpose for which they were intended, and a fair amount of latitude must be allowed for individual taste. But one could not but feel that in many cases, particularly as regards the cheaper types of glassware, these variations were not the result of deliberate attempts to meet certain problems, but arose through the haphazard way in which individual people decided on their own requirements, without any attempt to co-operate with others in fixing a common size or quality equally convenient to all of them.

It was advisable for the glass manufacturers to combine on this matter, but responsibility also rested with the makers

of lamps and burners, on which the sizes of glassware largely depended. As an instance of extreme needless variations, he might mention the differences in the sizes of burners for oil lamps or for petrol air gas-machines; small deviations were common, which could surely have no necessity as far as results were concerned, and the same held good to a greater or less extent in the gas and electrical industries.

In the case of oil lamps it is of course well known that the design of the lamp is necessarily affected by the kind of petroleum for which it is intended, and this may entail a difference in the dimensions of the chimneys. It should, however, be feasible to ensure that for lamps using the same kind of oil the sizes of chimneys are limited to standard sizes, which are found to give the best results. In this way greater uniformity as regards performance might be secured, besides materially diminishing the cost of manufacture.

In the United States co-operation between the makers of lamps and shades was more usual. The lighting unit, comprising both lamp and shade, was considered as a whole, the result being the standardisation of the conditions producing the best lighting effect, as well as enabling the unit to be most cheaply and expeditiously put together. Naturally time would be required in this country to bring the different makers into line. But it would be at least a great step forward if a series of standard sizes, considered the most satisfactory from a practical standpoint, could be determined upon and exhibited as those accepted by the lighting industry in principle. This would at once have the effect of bringing a number of makers into agreement, and others would follow.

This question of standardisation is of vital importance to the manufacturers of glassware in this country. So long as dealers were content to rely on imported glass divergencies in size were less important. But if glass manufacture is to be undertaken as a national industry on a large scale it is essential to limit as far as possible the present multiplicity of dimensions, as it is only by concentrating on standard forms that a substantial diminution of the cost of manufacture can be expected. Naturally, in regard to glass of a "luxury" type, where individual preferences play an important rôle, standardisation need not be carried far. But in regard to everyday articles which have to be produced in large quantities it should lead to most useful results.

Mr. Gaster also wished to associate himself with the remarks of Mr. Langlands on the testing of globes and reflectors. At present one could buy electric incandescent lamps by specification, and it seemed to him that ultimately one ought to be able to purchase globes and reflectors and shades for use with them under equally definite conditions. It was surely an anomaly to pay great attention to the illuminating power of the lamps, and then to abstain from stating precisely the qualities desired in the globe shade or reflector by which the rays of light were distributed. Mr. Stroud had referred to the pioneering work carried out by the Holophane Company in this respect, and during the last few years a great advance in this respect had been made by the various manufacturers of lighting appliances, who were now supplying polar curves with their lighting units. The time seemed ripe for adopting a standard method of procedure in testing and specifying such units, and he agreed that it would be a great advantage if the articles supplied by different companies could all be tested under similar conditions at a central laboratory. Here, again, he had in mind globes and reflectors employed for ordinary practical lighting problems. Fancy glassware of an ornamental kind would naturally fall into a different category, as definite predictions of the illumination provided were not so important in this case. But in commercial lighting the tendency was to standardise lighting units so that the illumination required could be specified beforehand and provided subsequently, and in order that this should be done successfully specification of both lamps and reflectors was needed.

As regards the qualities of glass required in the lighting industry, one of the most urgent problems was undoubtedly the production of suitable "heat-resisting" globes. The extremely valuable work done by the Glass Research Committee of the Institute of Chemistry had

shown what could be done in connection with laboratory glassware, and he thought that the extension of their researches, so as to include glassware required in the lighting industry, might lead to most useful results. The whole question was one for co-operation between the various parties concerned, and he welcomed the suggestion that the Illuminating Engineering Society should appoint a Committee to deal with the matter, and to promote the necessary co-operation with other institutions concerned.

Mr. W. M. MASON, speaking on the practical side from the gas point of view, said that five or six of the largest municipalities or companies in the United Kingdom had an annual turn-over amounting to no less than three million different items of glassware, of a value of at least £50,000. Perhaps this would be of some interest to glass manufacturers in encouraging them to cater for this trade. At the recent British Industries Fair he failed to find that any glass manufacturer was prepared to do anything on a really substantial scale, and it was put to him quite plainly that the position was that glass manufacturers would not put down £10,000 or £20,000 worth of new plant for the gas industry with the prospect that immediately the war was over orders would again be given to Austria and Germany.

In these circumstances, the formation of a Committee, which might make some working arrangement with the gas companies and municipalities to support those people who were prepared to invest money in the glass business, would be a useful step. He was delighted to find only yesterday that a Glasgow firm had come to the rescue and were actually making glass to replace Austrian glass, and were prepared to still further extend their activities in this line. He thought that the Society might suggest some means by which English, Scotch, and Irish gas undertakings would take a certain amount of their glassware from firms who were willing to go into the business; if this were done then he matter was solved.

Mr. R. W. HOOD (Edison and Swan United Electric Light Co., Ltd.), said that some degree of standardisation would undoubtedly be very helpful to glass manufacturers. In the electrical trade alone there were no less than 200 different types of bulbs, and he could not think that so many varieties were necessary.

He quite agreed that the scientific study of the composition of glass for various purposes was very necessary. At the same time he thought that those interested in the preparation of formulæ should recognise the practical difficulties in making glass to schedule. For example, there were some materials which could not be obtained in a state of perfect purity, and a minute percentage of certain impurities would at once exercise an effect on the colour or opacity of the glass. Such impurities might occur in the materials supplied for mixing, but might also even enter into the mixture by being absorbed from the material of which the pot was made.

Another important point was the temperature attainable. It was well known that the majority of the furnaces used in this country employed solid fuel, and in this case one could not conveniently attain the temperature reached in the gas-heated furnaces largely employed abroad. The furnaces answered perfectly for the kind of glass we in this country were accustomed to make, but could not at once be applied to making those glasses, hitherto mainly imported, which could only be made at a very high temperature. He hoped, however, that this country would shortly be in a better position in this respect.

The point deserved consideration, because it was quite possible to work out a formula which could be used for producing heat-resisting glassware on a small scale, but might be restricted in practical application, because few manufacturers had the facilities for applying it.

Further, the same mixture at different furnace temperatures may give entirely different results.

Mr. GUY CAMPBELL thought that it would be some years before English glass manufacturers would be able to provide the capacity to meet all the requirements of the lighting trade.

It might interest Mr. Langlands to know that with regard to the white

pressed glass variety of lines, although there have been attempts to produce this excellent quality of diffusing glassware in Europe, they did not meet with success. Its production is mainly a matter of formula.

With regard to artificial colour-matching, it is most satisfactory that with the improvement of illuminants the difficulty of colour-matching artificially grows less. Many years ago someone was responsible for the use of coloured glass in connection with the arc lamp to obtain a colour-matching unit. This was placed on the market in connection with "Jandus" arc lamp, but little is heard of it to-day. The glass plate with two films shown by Dr. Kenneth Mees before this Society, and which gives approximate daylight results with the tungsten lamp, has not been widely used, neither have the electric lamps mentioned by Mr. Langlands. It seems we must wait for the new unit which will give without assistance of any kind direct results before consumers will take kindly to artificial colour-matching units.

As to standardisation of quality, this was really a question of price. The higher the price the better the quality, and whilst there were two or three classes of customers a cheap market like India and an expensive market like this country, two qualities must be produced.

A standardisation of materials to be used in the manufacture of glassware is not likely to be appreciated by the manufacturers, who generally have their own views on the mixture they consider likely to produce the most satisfactory results; it would, therefore, be a difficult matter to procure, while possible improvements might be neglected.

The standardisation of designs, shapes, dimensions, etc., is a splendid idea from a glass manufacturing point of view, but any committee formed to deal with it would be up against a very big problem, because it would mean that all manufacturers of gas burners and lanterns, electric incandescent and arc lamps, would have to strictly follow the said lines, and therefore the existing tools, equipment, and in some cases patents of such manufacturers would be worthless. There was the aesthetic side to consider, because we did not always want to see the same size and shape everywhere; further, also, the human element came in here, because manufacturers invariably when they brought out something new wanted it to be different from any other product, apart from the logical fact that all improvements in lighting do generally and very considerably differ from its predecessor. Take the fish-tail burner and the modern high-pressure inverted incandescent gas burner; the first Edison carbon lamp and the latest gas-filled lines, all of which are in use, needing an entirely different glass accessory or ornament, while decoration is a fashion.

The suggestion that there should be an independent testing laboratory for all illuminating engineers was a good one and it might be arranged, for no doubt financial help would be forthcoming from the large gas and electrical undertakings.

Mr. Edward C. Barton, referring to Mr. Trotter's remarks on glass for transmitting light of various colours, absorbing or transmitting ultra violet light, &c., mentioned a very useful paper by Professor P. Mercanton, published recently I believe—in 1910 or 1911—in the Proceedings of the Société Vaudoise of Lausanne. This contained a very complete summary of the qualities of special varieties of coloured glass, the results of photometric and spectroscopic analyses being given.

Mr. George Herbert exhibited three very unsatisfactory screwed well glasses of English manufacture; all were selected from the same consignment and all supposed to be of the same dimensions, quality, &c.

He explained that whereas one was very light and brittle, another was too small for the screw it was intended to fit, whilst the third was too large.

The object of showing these glasses was to impress upon the manufacturers of this country the necessity of making a standard article which would be acceptable for use in explosive factories (as it is usually stipulated that these glasses must not exceed certain dimensions), and on account of the English manufacturers not meeting these requirements, orders have passed them and been placed with firms abroad.

MR. ED. DOBBINS (*communicated*): Your invitation to participate in the Discussion at the last meeting of the Illuminating Engineering Society on some aspects of the design and use of window glass for Natural Illumination was much appreciated, and I am sorry that I found it impossible to attend. I have, however, much pleasure in sending a short written contribution on the subject.

The design of such glass forms quite an important section of glassware used for lighting purposes, not only in connection with admission of light through windows in the case of buildings overshadowed by neighbouring obstructions, but also as regards pavement lights, &c., for basements and underground passages.

During the last few years I have visited a very large number of factories in this country, and have been struck by the care some proprietors bestow on the frequent cleaning of window glass and the preservation of a light tint for ceilings and walls, by which alone a very great improvement in the amount and distribution of light has often been obtained. Seeing how great a proportion of the work of a factory is carried on by daylight, the proper utilisation of daylight is surely of commercial importance, both in its relation to the amount of work done and its influence on the ease with which operations can be carried out, and in view of the hygienic value to the workers of good natural illumination. In the case of buildings of a somewhat antiquated type, with small windows, or buildings where the loss of daylight through the obstruction of trees or surrounding buildings is considerable, the use of accessories to increase the amount of light entering the rooms is particularly important. For this purpose light refracting glass panes which serve to divert into the room a considerable amount of downward light, which otherwise would not be utilised, is frequently of considerable service ; if, by such means, the duration of time during which the room can be lighted by natural means without it being necessary to employ artificial light can be even slightly increased, the resultant saving may more than compensate for the cost of installing the special glass. Another point to be noted is that in many cases it is essential that a form of glass should be used which obstructs the vision from within or without ; therefore it is worth while to select a glass which, besides having the necessary obscuring effect, increases the percentage of daylight available. I understand that the Society has devoted attention to the question of specifying for buildings a minimum percentage of the total unrestricted daylight illumination which should find access to a soom Properly designed window glass would often be useful in bringing this figure up to the proposed value.

As regards the nature of this special prismatic window glass, the correct shaping of the prisms so as to diffuse the light longitudinally and horizontally, so that inconvenient shadows are eliminated and the light is directed into the room at the requisite angle, requires some care. The design of the surfaces is also affected by practical conditions. For example, some forms of glass have too many lines on their surface, making them very difficult to clean, and causing an obstruction of 20—30 per cent. of the light. It must also be borne in mind that the allocation of window space in a room is usually a compromise between lighting and heating conditions. As ordinarily used the glass should redirect the light in such a way as to increase substantially the illumination at points in the room most distant from the window, this securing additional light without structural alterations. In very hot and sunny districts, however, this may occasion an undesirable rise in temperature. In such cases we have sometimes installed the glass in the reverse position so as to direct the light upwards on to the ceiling. This method of working on the "indirect lighting" principle with daylight gives excellent diffusion.

Naturally the degree to which the rays of light are diverted depends on the quality of the glass, and for our purpose glass having a comparatively high index of refraction is essential. The glass should also be colourless and transparent. We have no difficulty in getting the desired kind of glass manufactured in this country.

MR. H. HUGH WALFORD [Messrs. Chance Bros. & Co.] (*communicated*):—I regret

that pressure of work does not permit my being present to hear and discuss the many interesting points so ably introduced by Mr. Langlands. I should have been glad of the opportunity of drawing attention to the many difficulties with which one is surrounded at the present time in endeavouring to meet the urgent and sudden demand brought about by the war for heat resisting glass.

Members present will fully appreciate that skilled glass workers are not only extremely scarce, but are in exceptional demand for the manufacture of other kinds of glass vitally important to the nation at this juncture. Moreover the manufacture of heat resisting glass of Jena quality is entirely new to us, and there are many special features in connection with it which are full of difficulties at the present time.

I mention these points in order to solicit the patience and consideration of lamp makers and others. We have succeeded in making heat resisting glass similar to the Jena glass, and we are to-day sending out globes which we are given to understand are in every respect equal to or better than the German product. Our output is of necessity limited by the exigencies of present conditions, but we hope that with the co-operation of buyers we may before long be able to meet the demand.

There is practically only one direction in which this co-operation can materially assist this result, and that is the standardisation of sizes, to which Mr. Langlands has referred. There are scores of varieties of globes almost identical in shape and weight, but differing by millimetres in rim diameter or in other dimensions which are in no way essential to the purpose for which the globe is used. This sort of thing makes it utterly impossible for a manufacturer to keep a stock, and also adds materially to the cost of the individual globes. It might not be so serious if labour and other things such as materials and fuel were plentiful and the demand normal, but in the present circumstances, it is simply checking and hampering the progress of the manufacturer, and giving rise to considerable hesitation as to the advisability, or even possibility, of seriously going into the trade on permanent commercial lines.

I do press most earnestly the point of standardisation of sizes and shapes, without which it is hardly too much to say that the future of the manufacture of heat resisting glass in this country can scarcely hope to be established.

Messrs. Stevens and Williams Ltd., Stourbridge, write as follows:—"We have given a good deal of attention to lighting glass but mostly for artistic lighting in private houses. We are in accord with the expressions in the address as to the need of standardising various kinds of glass and the dimensions of the glassware used in the lighting industry, but it seems to be a problem of considerable difficulty. Owing to the scientific knowledge of glass gained by the Germans through the establishment of the Jena laboratories, they were able to capture the bulk of the lighting industry, and we feel confident that if efforts were made in the direction of scientific investigation in this country, backed by the Government, England would be in a far better position than formerly to compete in the markets of the world."

Mr. W. C. Clinton (*communicated*): I have read the copy of the paper which you kindly forwarded to me and consider it highly suggestive, although one cannot quite agree with all the proposals made by the author.

It is doubtful whether we have attained that pitch of perfection in the manufacture and design of glassware that would make standardising desirable as suggested in proposals (1), (2) and (4), but (3) and (5) are deserving of serious attention.

Behind all this, though, lies the question of the Governmental attitude to specialised industries in general.

Alderman R. Burtles [Messrs. Burtles Tate and Co.], Member of the Lighting and Gas Committees of the Manchester Corporation (*communicated*):—I have read with considerable interest the paper by Mr. Langlands, a proof of which you kindly sent me, and much regret being unable to be present at the discussion.

Since the war our firm, along with other firms, has gone in for glass-

ware for lighting purposes and I can fully endorse the importance—the very great importance—of standardisation not only of the materials used in the various kinds of glassware used in the lighting industry but also in the sizes of the glassware required. At the present time every lamp maker seems to go in for a special size of his own, causing, as Mr. Langlands states, much inconvenience besides making it necessary to carry so much extra stores. Even railway companies are the same in this respect, almost every company having its own sizes of glass bowls for lighting the carriages.

With regard to heat-resisting properties of British-made glass globes there is a great deal to be said in regard to the regular distribution of the glass throughout the globe and the reason these globes are now so much improved since the British manufacturers commenced making them is that the operative glass maker, being continuously making various sizes of globes has, by practice, become more efficient in this respect, blowing the globes out more regular in thickness. It must follow that irregular distribution of glass, leading to variation in thickness of the globe, makes it more difficult for them to withstand the varying temperatures to which they are subjected. Hence it is questionable whether *all* the blame attributed to the composition of the glass is due to that cause alone; and as it is expected that this trade will remain in the country after the war there is no doubt that British manufacturers will be able to work up to the necessary efficiency.

In my opinion the addition of a certain amount of lead oxide (red lead) to the composition of the mixing tends to mellow the glass, enabling it to be worked more uniformly, and would also tend to assist the contraction and expansion caused by the varying degrees of heat inherent to their use.

Mr. DUNCAN WEBB (Messrs. Molineaux, Webb and Co., Ltd.): The decline of the glass industry in this country is mainly due to costs of manufacture. The German and Austrian glasses are very inexpensive, and the readiness with which they break is accountable for the enormous trade. Good quality is never attained at a low cost.

I think comparative tests of glasses of different chemical composition and physical properties, construction, &c., would result in the production of a better article than the imported varieties. Such tests should be on a practical scale, not merely laboratory research, and the cost should be defrayed by the Government. Unless, however, the manufacture can be carried on in this country with profit, this will not revive the industry.

As regards the technical question, I would remark that lead does not cause "fog," as I understand the term, and I have made thousands of tons of lead glass. The cause is well known, and the fault occurs in any glass of unstable composition.

Mr. F. W. THORPE, Verity's, Ltd. (*communicated*):—We are still dependent upon foreign suppliers for glassware principally for the reason that an English maker will not, or cannot, blow or press other than prismatic glass into a mould; therefore one dreads to adapt English white glassware for semi-indirect lighting for the trouble that ensues. Further, we are unable to develop lighting fixtures to our own ideas through failure in finding a glassmaker to carry them out, and, consequently, being forced to employ pressed glassware from America, which, in many instances, is first imported from the Continent.

Occasionally one finds a bowl or shade well thought out in design and which it is possible to use on a good lighting fixture, but what gain or advantage is there in using the productions of other countries, being always compelled by lack of local supply to follow, instead of to lead, others in ideas concerning illumination? We could produce designs more suitable to our own requirements if a source of manufacture could be found.

Much could be done by co-operation between the glassmakers and the Illuminating Engineering Society as suggested by Mr. Langlands, especially with a view to standardising bowls and reflectors required for commercial and general lighting, which would undoubtedly assist in the establishment of a sound British glass industry. The serious shortage of good

glassware, and the necessity for avoiding large size bowls, is leading to the evolution of a new type of fixture in the form of a series of three, five or more small English bowls supported by metal, or other material, designed to support the glass without in any way causing inconvenient shadows. This system is very convenient for it avoids the use of single high units which are very expensive and which, for reasons of economy, are being substituted by a series of smaller half-watt lamps. This system obviates the use of imported glassware and architects have been quick to realise—judging from recent domestic and public installations—that this method of lighting lends itself so much more to variety of decorative treatment than the bowl type of fixture one sees in every shop, invariably of the same outline, and nearly always the same in illuminating effect. One welcomes a design away from their monotony. The present glass difficulty is rapidly leading to the development of a new type of scientific lighting fixture.

Mr. S. B. Langlands, in reply, expressed his thanks to the meeting for the very interesting discussion which had taken place upon his paper. He was glad to be confirmed in his view as to the manner in which the Board of Trade had helped in many matters since the war. His experience was that the Board was always ready to step forward and try to assist, and in his opinion the Board had risen to the occasion as far as their limited opportunities had allowed.

As to standardisation, he appreciated the need for avoiding hardship or limiting progress, but he thought at present there were needless variations. The matter had been brought to his notice by the electrical engineer in one of the boroughs in connection with the question of arc lamp globes. He (Mr. Langlands) was at the time using one type of globe with two or three types of lamps, his department adapting the globes in order to obtain satisfactory distribution of light in each case. It would seem that these differences were multiplied more from human caprice than any real necessity. He was glad to have Mr. Stroud's remarks on standardisation and he still held that there could be a very large amount of standardisation without interfering with development and ingenuity. Rational standardisation was required.

He hoped that the Institute of Chemistry would extend their good work to lighting glassware. He could quite understand that glass makers might experience difficulties applying some formulae, but these workshop difficulties were eventually overcome. The glazing of workshops had been mentioned in one of the letters read by Mr. Dow, and in this connection it might be interesting to say that one of the big munitions factories in Glasgow had been constructed from glass from top to bottom, and from the daylight lighting point of view was one of the most ideal workshops in the city. Moreover when working at night with artificial light the glass contributed a considerable amount of reflected light.

Mr. Trotter had referred to opal glass, and America had undoubtedly made great developments in this branch. In this connection he would like to draw attention to a paper published in America called the "American Glass Budget." In the last issue of this, a lot of good information was published. The Americans were bringing in machinery for doing by centrifugal forces what had hitherto been done by the blowpipe.

A hearty vote of thanks was accorded to Mr. Langlands at the conclusion of the discussion.

PERSONAL.

An agreement has been concluded with Mr. Clifford C. Paterson, M.I.E.E., A.M.I.C.E., principal Assistant in charge of Electro-technical and Photometric Buildings at the National Physical Laboratory, to join the Osram-Robertson Lamp Works Ltd. as Director of Laboratories for Research and Technical Manufacturing purposes. The arrangement will commence at the conclusion of the war or before that date, if possible.

THE CANDLEPOWER OF SERIES GAS-FILLED LAMPS.

It is well known that the distribution of light from half-watt lamps varies considerably and that the ordinary method of rating such lamps in terms of the horizontal candlepower is unsatisfactory.

Some useful evidence on this point is contained in some experiments by R. C. Robinson, carried out in the United States* on four types of series gas-filled lamps having filaments respectively vertical, horizontal, diagonal and V-shaped. For these four lamps the following data were obtained :—

Filament mounting.	Volts.	Amp.	Watts.	Mean Horizontal.		Mean Spherical.		Reduction factor.
				Candle power.	Watts per candle.	Candle power.	Watts per Candle.	
V shaped	9·5	6·97	66·2	100·7	0·66	82·5	0·805	0·82
Vertical	10·76	7·02	75·5	126·8	0·595	93·7	0·805	0·74
Horizontal	10·73	7·07	75·9	93·5	0·82	95·2	0·800	1·01
Diagonal	11·2	6·93	77·5	122·0	0·635	97·2	0·815	0·78

In view of the varying character of the reduction factor it would seem that such lamps are best specified in terms of their mean spherical and not their mean horizontal candlepower.

LIGHTING A SMALL ART GALLERY WITH GAS-FILLED LAMPS.

In a recent number of the *Electrical World* the lighting of J. J. Hill's private gallery at St. Paul, Minn., U.S.A., is described by A. L. Abbott.

The gallery is equipped with a skylight and the artificial illumination was provided by installing above the glass a series of gas-filled lamps with concentrating reflectors. The lamps were inclined so as to direct the light diagonally on to the walls of the room and in this way an illumination of about 6½ foot-candles was evenly distributed over the wall-area. It is pointed out that this method is much more convenient than the production of uniform illumination by means of a diffusing glass ceiling and the difficult problem of securing even illumination over the expanse of wall is quite economically and satisfactorily solved.

The light enters the room in a similar manner to daylight and the lamps being quite out of the range of view from the floor there is no risk of glare. In this room there are forty-four 100-watt gas-filled tungsten lamps installed. The expenditure of energy works out to 42 watts per linear foot of wall.

* *Lighting Journal*, March 1916.

HEADLIGHTS FOR RAILWAY-TRACK LAYING.

A recent article in *Popular Mechanics* describes the construction by night of a strategic railway in South Africa. As the railway was being built the foremost truck carried a 50 ft. boom projecting in front of it and bearing a series of 100 cp. electric lamps mounted in reflectors and throwing the light downwards on the section of track being prepared. The truck also carried a pair of projectors for casting a horizontal beam on the more distant parts of the track, illuminating it for a distance of 120 feet. A strong downward illumination was thus continuously directed on the portions of the track under construction, and as the train moved forward on the newly laid rails a new section would be continually lighted up ready for work. The electricity for the lamps was derived from a dynamo driven from a 5 h.p. oil engine mounted on the truck.

A SUGGESTED CODE OF LIGHTING FOR FACTORIES, MILLS AND OTHER WORK PLACES IN THE UNITED STATES.

Presented at the Ninth Annual Convention of the Illuminating Engineering Society, U.S.A., held in Washington, September 20th to 24th, 1915 ; abbreviated.)

(*Concluded from Vol. VIII., page* 455.)

Section X. Systematic procedure should be followed in changing a Poor Lighting System over to an improved arrangement.

Using the Shop Force.—In large factories or mills, a wiring or gas fitting force is sometimes a part of the maintenance division. The work of the wiremen or fitters is likely to be heaviest in the winter due to the dark days. Where this condition exists, there is all the more reason to apportion out new work so as to accomplish it during the months of least wiring and piping repair activity, and further, at that time of the year when employees will be comparatively unaffected by the disturbances usually associated with a change from an old to a new lighting system through possible irregularities in the illumination service while the wiremen or fitters are at work.

Distribution of Expense.—Another feature different from the foregoing viewpoint, is in the distribution of the installation cost over a relatively long interval. If, for example, the system is desired for the approaching winter, the complete wiring or piping plans may be drawn up and blocked out into three, four or even more sections, thus spreading the expense over as many months.

Yearly Appropriation.—In some shops a given appropriation may be allotted each year for building equipment. From the standpoint of finance plans, it may thus be desirable to distribute outlays of this nature over the year, rather than to concentrate them at any one time. *An important consideration in this method of installing lamps, however, is to prepare in as far as possible the complete plans in advance, at least as regards given factory or mill sections, so as to insure a uniform and symmetrical installation as a whole when the component parts are finished.*

Section XI. Reflectors and Their Effect on Efficiency.—A reflector or shade is used in conjunction with a lamp for the purpose of reducing the glare otherwise caused by looking directly into the bare lamp, as well as for the purpose of redirecting the light most effectively to the work.

Reflectors and shades are now obtainable so designed as to be specially adapted to give sizes and types of the smaller and medium sized line of lamps, and hence care should be used to be sure that both reflectors and lamps are of the correct size in their relation to each other. This is of the utmost importance in securing uniform illumination for a given spacing distance and mounting height of the lamps. For a certain ratio between the spacing and the height of the lamps, a reflector can nearly always be selected which will furnish uniform illumination over the working surface. (These remarks concerning reflectors apply particularly to lamps of the tungsten type and to small gas units.)

Function of Reflector.—Owing to the direction of the light from the lamp, nearly all types of lamps, in addition to the downward light, furnish some rays which go upwards and away in other directions from the objects to be illuminated, and are therefore relatively not useful. Furthermore, a bright source in the field of vision, causes an involuntary contraction of the pupil of the eye, which is equivalent to a decrease in illumination in so far as the eye is concerned. Hence, while reflectors or shades may at first seem to reduce the amount of light in the upper part of the room, their use actually increases the amount of light in a downward useful direction, and improves the " seeing " due to the better conditions which surround the eyes. The economic

function of the reflector as contrasted to this easier conditions it affords the eyes, is to intercept the otherwise useless or comparatively useless rays which do not ordinarily reach the work, and to reflect them in a useful direction. In performing this function, there is a choice through the design of the reflector, in the manner of distributing the light so as to make the illumination on the floor space uniform with certain spacing distances and mounting heights as previously mentioned.

Avoiding Dark Spots.—With the use of lamps for which a large variety of reflectors is available, the proper reflector should therefore be chosen so as to give the desired distribution of light. In other cases, as in the use of the gas or electric arc lamps, where the globe or reflector is usually a fixed part of the lamp, care must be exercised to space the lamps at sufficiently close intervals to insure uniformity of the illumination, that is, a freedom from the relatively dark spaces which exist between lamps when spaced too far apart.

Light Interiors.—With a light ceiling, the reflection of that part of the light which passes through a glass reflector to the ceiling, and which is added to the light thrown downward from the under surface of the reflector, is a factor in building up the intensity of the illumination on the working surface. *Great importance is therefore attached to light interior colours, especially on ceilings and the upper portions of walls, both in reinforcing the direct illumination, and in giving diffusion, which in turn adds to the amount of light received on the side of a piece of work. It should also be stated that the intensity of the light from bare overhead lamps when measured on the working surface may be increased by as much as 60 per cent. through the use of efficient reflectors.* This is due to the utilization of the horizontal rays of light as previously stated, which predominate in the bare lamp, whereas the most effective light in factory and mill work is apt to be that which is directed downward.

Glass and Metal Reflectors Compared.—The question is sometimes raised as to the use of glass reflectors in connection with lamps for factory and mill lighting. This question is largely one of economy and maintenance, and it may be answered either in an off-hand way or on a basis of practical experience with both types.

In large installations of small units there has been an effort to establish the merits of glass and of metal reflectors, by equipping lamps in adjacent bays with glass reflectors in one case and with metal reflectors in the other. It has been found almost invariably that if the choice is left to the workmen and superintendents, glass reflectors will be given preference over metal, mainly on account of the added cheerfulness they produce. If, therefore, the first cost and maintenance expense of the glass reflectors is practically the same as with metal, then glass may be employed to advantage.

Reflector Efficiency.—Glass reflectors on the market are capable of producing an amount of illumination equal and even greater in some cases than that produced by the best metal reflectors, and even if the first cost is somewhat higher, the added advantage of glass as opposed to metal is usually sufficient to make the small difference in cost a negligible item. This factor is all the more noticeable when one considers that the reflector itself is a small part of the total cost connected with the wiring or piping of the lamp and its reflector.

Pierced metal reflectors are also available. These are designed with small openings at the upper portion of the metal so that the reflector may give the same distribution characteristics as a given glass reflector, thus affording a suitable metal reflector for use where glass may be objectionable. Some of the advantages of the pierced metal reflector are that it is unbreakable and that accumulations of dust on the outer surface do not decrease the efficiency. It is also true that the light which passes through the openings in this reflector to the ceiling cannot be diminished by dust on the outer surface as in the case of glass reflectors. (This type of reflector is shown in Fig. 8 under the main line shafting.)

Reflector Maintenance.—Regarding the maintenance of glass reflectors under rough factory and mill conditions, it may be stated that glass reflectors are used quite widely with almost a negligible increase due to breakage. Thus, out of

the total maintenance cost in one representative installation, it was found that the charges were proportioned as follows :

Renewals, cost of lamps (tungsten)	75 per cent.
Renewals, broken glass reflectors	3 per cent.
Labour, making renewals and changing reflectors for washing	16 per cent.
Labour, reflector washing ..	2 per cent.
Additional indirect charges ..	4 per cent.
Total	100 per cent.

Points to Consider.—Reflectors will not be classified here from the commercial standpoint, but the following items should be given consideration in the selection of the type of reflector for factory or mill use.

1. Utilisation efficiency: how much does the reflector contribute to the effective illumination on the work ?
2. The effect in reducing glare.
3. Natural deterioration with age through accumulations of dust and dirt.
4. Ease in handling and uniformity of manufacture.
5. Physical strength and the absence of projections which may increase the breakage in case of glass reflectors.

A study of the various reflectors on the market with the aid of these items as a basis, will determine what reflectors are best adapted to given conditions. Regarding the third item in the foregoing list, it may be stated that under comparative tests in service, the accumulations of dust and dirt on glass reflectors do not seem to be any greater than the coating of dirt which accumulates on the inside of a metal reflector in the same length of time.

Section XII. Side Light Important in Some Factory and Mill Operations.—It has been customary in many cases to measure the effectiveness of illumination in terms of the vertically downward component of the light. This method has ignored the value of side components in relation to vertical surfaces and openings in the side of the work. It is sometimes more necessary to light the side of the machine or the side of a piece of work than the horizontal surface. If, then, in designing a factory or mill lighting system, the prime object is the production of the greatest amount of downward illumination, it may happen that the side component is so small that the sides of machinery or of work are inadequately lighted.

Two Ways to Secure Side Light.—Experience indicates that there are two general ways in which to secure adequate side lighting. One of these methods is to lower the lamps, and the other is to use broader distributing reflectors than are called for by the rules which consider uniformity of the downward illumination only. Side walls or other reflecting surfaces will modify the results. Thus, after the determination of a certain type of reflector for producing uniform vertically downward illumination, it may be found that more side light is necessary, and this extra side component may, as stated, usually be secured by selecting a somewhat more distributing reflector. Broader distributing reflectors are apt to result in less downward illumination and will sometimes call for larger lamps than found necessary by preliminary calculations.

Practical Case.—As an illustration, in a certain lighting system a vertically downward intensity of about 3 foot-candles was deemed sufficient for the work involved. Measurements and observations showed that the side light was insufficient. In this particular installation it was found necessary to produce a vertically downward intensity of about 5 foot-candles on the average in order to secure an intensity of about 2 foot-candles on the side of the work, and also to use a somewhat broader distributing reflector than at first chosen. Two foot-candles on the sides of the work were sufficient in this case where bench work and work in the vice on small machine parts were conducted.

Keeping the Lamps High.—It is recommended that the lamps be mounted near the ceiling in all reasonable cases where side light is necessary, and that the side light be increased, *not by lowering the lamps*, but through the medium of broader distributing reflectors and larger lamps, if required. This attitude is taken on account of the glare which results when lamps are mounted too close to the work, a feature most noticeable in the absence of a reflector or where glass reflectors are used.

Section XIII. Maintenance.—The importance of system in the upkeep of natural and artificial lighting equipment may not appeal to every reader at the outset, but a consideration of the points involved will indicate that neglect of such work is apt to result in excessive losses of otherwise useful light.

Windows.—Factory and mill windows become covered in time with dirt, and produce greatly decreased values of natural light in consequence. These losses may easily be great enough to affect the workmen seriously, and to necessitate the use of artificial light at times when otherwise it would not be required. Dark surroundings also increase the likelihood of accidents. Regular window cleaning should therefore be a part of the routine of every factory and mill building or group of buildings.

Lamps.—Carbon filament, mercury vapour, gas mantle and tungsten lamps burn out or break, globes and reflectors become soiled, and the various other items of deterioration take place so gradually that in many cases they are given no special concern in the practical economy of the shop. Moreover, it is hardly necessary to mention the fact that often lighting systems are allowed to deteriorate to an extreme point and nothing is done unless complaints come in from employees after the lighting facilities here and there throughout the shop have become so poor that work has to be discontinued temporarily. The losses of time from such circumstances, when added up throughout a year, are more than likely to exceed the expense of systematic attention to such maintenance items in advance.

Overhead System.—Furthermore, with modern methods where the lamps are usually mounted overhead rather than close to each machine, the importance of relieving the workmen from any care of the lamps and placing it in the hands of a maintenance department is even greater than has been the case in the past, particularly in large plants. In one large factory all burned-out lamps are renewed each day except Saturday and Sunday, these renewals being based on a daily inspection of every lamp to ascertain whether or not it is in working condition.

Lamp Renewals.—It is found that the renewals are considerably greater on Monday than on any other day of the week, this increase being due to renewals not given attention on the two preceding days. Obviously, therefore, a continued neglect of the inspection and renewal of these lamps would soon result not only in inferior lighting conditions, but to large losses of time for the employees, not to speak of the annoyance involved.

Reflector Cleaning.—Serious loss of light may occur when globes and reflectors are allowed to go for long periods without cleaning.

In one particular case, which is a typical one, the loss of light at the end of the four month interval, amounted to about 50 per cent. The cost of electrical energy in this shop was such that the loss of light during the four months amounted to about 12 cents, while the total cost of taking down, washing, and replacing this reflector amounted to about 3 cents. The economy of a fairly frequent attention to cleaning of such reflectors is at once apparent, even if the improved condition of the light in itself be ignored.

The examples just given, in the one case associated with the renewals of the lamps, in the other with the washing of the reflectors, will serve to illustrate the class of upkeep problems which are involved in shop lighting. The most forcible emphasis is applicable to the idea that system may properly be called a first step towards success in this line of maintenance work.

A Method of Inspection and Maintenance.—In one large factory a regularly developed method of inspection and renewals is employed. As an example, the method as applied to several thousand tungsten lamps, which are in service in the various buildings, will be described. All the lamps are inspected once per day, except Saturday and Sunday. A regular route is followed by the inspector, and all burned-out lamps, broken switches, loose fuses, and similar items are noted. Careful observation is also made of reflectors which appear to need washing and any other points which might affect the efficiency of the system, after which a report is made up about noon and promptly sent to the maintenance depart-

ment to permit all renewals and repairs to be made before night. In this manner the lamps are well maintained from day to day.

Marking Columns.—To facilitate this renewal work, it has been found advantageous to mark all columns through this shop. The inspector is thus enabled to indicate clearly the location of each burned out lamp and the renewal man to locate it without delay. It is helpful now and then in like manner to have the inspector note the unnecessary lamps found burning when artificial light is not required. If lamps are found burning at such times, a note sent to the head of the department calling attention to the matter, is usually sufficient to remedy the difficulty.

Noting Soiled Reflectors.—As a check on a regular cleaning schedule, the inspector should note all reflectors in need of cleaning. The frequency of each cleaning will depend on the rate of deterioration due to the settlement of dirt on the surface of the glass or metal and also on the surface of lamps, and the fact should be kept in mind that the amount of dirt on a reflector is nearly always deceptive, that is, reflectors which have suffered a large deterioration in efficiency due to dirt often appear fairly clean, and for this reason it is best to increase the frequency of cleaning somewhat over that which seems sufficient from observation, particularly in view of the fact that tests indicate large reductions of light from apparently small accumulations of dust and dirt.

A Method of Washing.—In the factory just referred to, all reflectors are removed to a central washing point. Where the number of reflectors to be hauled is large, a truck is used. Often, however, where only a small number of reflectors is to be transported, small hand racks, devised for the purpose, are employed. When an installation is in need of washing, the scheme is to haul sufficient clean reflectors to the location in question. The soiled reflectors are then taken down and clean ones immediately put into place, after which the soiled reflectors are removed to the central washing point, washed and put into stock for the next location.

Section XIV. Expert Assistance Suggested.—The advantages of securing expert assistance in dealing with illumination is strongly emphasised. The points which come up for solution are complex and require, in many cases, the judgment of one who has had wide experience in the lighting field. In particular, anyone who undertakes to adopt any part or all of these suggestions, will do well to secure the co-operation of a lighting expert capable of interpreting the legislative articles and of advising in a constructive manner.

Section XV. Other Features of Eye Protection.—Care is urged on the part of those responsible for the health and welfare of employees to see that adequate eye protection is afforded in all operations which are apt to cause injury to eyesight, if such protection is neglected. As typical of such other causes of danger to eyesight, arc welding may be mentioned, where the operator, according to accepted practice, must wear a helmet serving as an eye shield as well as a shield for the face and head in general. *Protective glasses for this purpose should not be judged as to their protective properties by mere visual inspection. They should, however, be analysed for their spectral transmission of invisible radiation.* Protective measures should also be taken to prevent on-lookers from being unduly exposed to such eye dangers, by enclosing the welding operations with suitable partitions. These general remarks apply with equal force from the standpoint of those handling the operations to such other cases as the testing of arc lamps, inspection of hot metal, and similar cases.

Section XVI. Auxiliary Systems for Safety.—The auxiliary system of lighting called for in Article XI of the Code, is a safety first precaution which is insisted upon in a large proportion of the 1,200 buildings coming under the control of the Bureau of Water Supply, Gas and Electricity in New York City, particularly such buildings as are occupied by large numbers of people. The same precaution is now observed by the Bell Telephone Company's offices fairly generally throughout the country, also by a large number of private manufacturers and by local ordinances compelling all types of amusement places to take this precaution.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

EFESCA LANTERNS FOR HALF-WATT AND VACUUM TUNGSTEN LAMPS.

This new catalogue, issued by **Messrs. Falk, Stadelmann and Co., Ltd.** (839-87, Farringdon Road, London, E.C.), contains particulars of a great variety of lanterns.

We notice several other useful types for interior lighting, for example, the "Bodmin," which appears to cover the filament very completely, and would no doubt give a useful downward illumination. Another attractive model is the "Burnley," in which the globe is mounted on a pedestal, suitable for placing on posts or pillars.

A very considerable proportion of the lanterns shown utilise clear globes for half-watt lamps. Although public taste has no doubt set the standard in this respect in the past we hope that after the war experience of present conditions will induce people to be satisfied with a more subdued system of lighting, thus encouraging a more general use of diffusing globes and reflectors.

A page is devoted to the Holophane E, I, and F, industrial units, and the compilers have tabulated the matter as regards price, spacing and illumination provided in a very convenient and serviceable way. It is worthy of notice that these complete data are only given for the Holophane units. We hope that in the future this practice will become more general.

THE LIGHTING OF A LARGE SHIP-YARD OFFICE.

THE three illustrations on this and the opposite page show the system of lighting supplied by the British Thomson-Houston Co. Ltd. through the Newcastle-on-Tyne Electric Supply Co. Ltd., for the new offices of Sir W. G. Armstrong Whitworth & Co. Ltd. (Wallsend-on-Tyne). It is stated that no fewer than 450 lighting points are used in this scheme, and we understand that it is the first office installation in the Newcastle district to be equipped throughout with Eye-Rest and semi-indirect fittings.

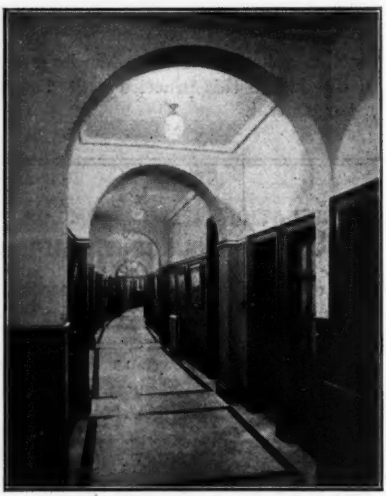

FIG. 1.—Corridor lighting at Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on-Tyne.

Fig. 1 shows the system of corridor lighting. The passages are arranged in a curve so that some thought is required in order to space the lighting units conveniently and at the same time to obtain uniform and adequate illumination. The problem has been met by the use of small spheres of ribbed Alabas glass.

In Fig. 2 we have an example of the system of lighting in the tracing and general offices, where semi-indirect fittings are employed. With the indirect system the source of light is of course completely hidden, and for this reason many have expressed the view that there is "something wanting" in the effect. To meet this objection one may employ semi-indirect fittings of the type shown in Fig. 2, which can be mounted close to the ceiling and are therefore useful in cases where it is desired to get an even illumination over the room, and to keep the lamps high up out of the direct range of view. In the general offices 300-watt gas filled lamps are used, in the tracing office similar lamps of 200-watt consumption.

Another variety of semi-indirect fittings is shown in operation in the Directors' Office (Fig. 3). This apartment is lighted by two "Eye-Rest" pendants, with 24 in. luminous panelled composition bowls, each fitted with two 100-watt Mazda lamps. This fitting is really a modification of the Eye-Rest Indirect unit, the lower portion of the bowl being of white or coloured glass instead of being opaque. No alteration has been made in the internal equipment of the bowl, with the exception that a lamp of quite small candlepower, enclosed within a diffusing globe, lights up the lower translucent portion, thus removing the dark effect of the indirect system, without prejudicing the distribution of light. Bowls of this class can be supplied with glass of special colours, selected in order to harmonise with the general scheme of decoration of the room. The construction of these units is interesting, the principle apparently being to regard the light from the supplementary small lamp as serving simply to produce the desired luminous effect over the lower portion of the bowl, without apparently contributing any very appreciable direct lighting element to the illumination; in this respect the system is somewhat different from semi-indirect methods in which the direct downward component plays a considerable part in the illumination, and the shadow conditions would presumably approach very near to those obtained with pure indirect lighting.

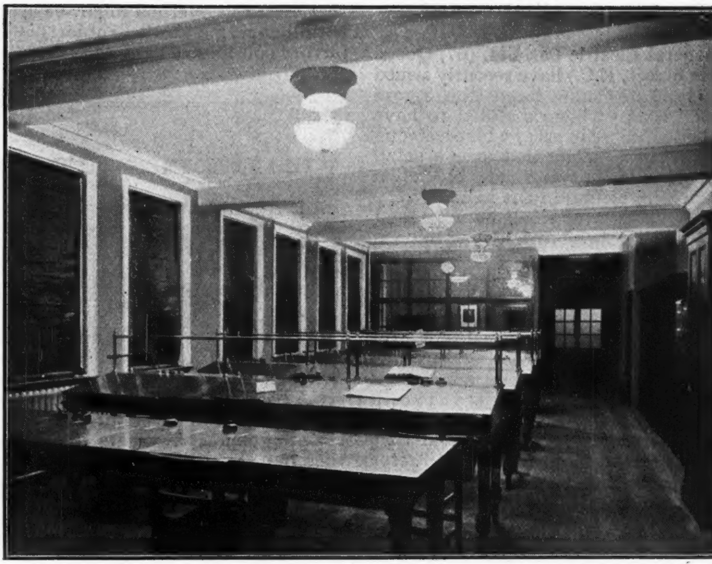

FIG. 2.—Semi-indirect lighting in the General Office of Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on-Tyne.

FIG. 3.—Lighting of the Directors' Office of Sir W. G. Armstrong Whitworth & Co., Ltd., Newcastle-on- Tyne, with semi-indirect composition bowls.

THE OSRAM AXIAL LAMP.

THE **General Electric Co., Ltd.** (67, Queen Victoria Street, E.C.) have recently issued a new type of Osram lamp (the Osram "Axial" lamp) which is stated to have special advantages in cases where a strong light must be concentrated over a small area. The filament is made of drawn tungsten wire wound in the helix of very small diameter, and arrange within a comparatively small space. The upper half of the bulb is covered by a conical opal reflector, and by this means an exceptionally strong downward illumination is obtained. It is recognised that the concentrating power of any reflector depends materially on the dimensions of the filament, and no doubt the compact nature of the filament in this case is instrumental in assisting the accentuation of the light in the desired direction.

The lamp is expected to be particularly useful for lighting desks, machine tools, showcases, shop windows, etc., as well as for fine work such as jewellery, watch and clock-making, etc.

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A USEFUL METHOD OF GIVING WARNING AGAINST ZEPPELIN RAIDS.

During the last few months there has been much discussion on the best means of warning people of the approach of Zeppelins. Obviously the best method would be one which gave adequate warning to every householder but could not be heard or seen by hostile aircraft.

According to the *Journal of Gas Lighting*, in one of the cities in Scotland the warning was recently conveyed from the central electric supply station by producing a temporary fall in voltage, thus causing the electric lamps to glow a dull red. It is contemplated that a similar method may be applied in connection with the gas lighting, the proposal being that the pressure in the mains should first be reduced and then, when the householders have been warned by the diminution in light to turn off all the burners, the supply of gas should be cut off completely. It appears, however, that even this method might be attended with danger, and the subject is being further considered.

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THE EMPLOYMENT OF WOMEN.

An Appeal to Employers has been issued jointly by the Home Secretary and the Board of Trade, pointing out the need for special measures to replace by women the men now being called up for the Army.

"There is one source, and one only," it is pointed out, "from which the shortage can be made good—that is, the great body of women who are at present unoccupied or engaged in work not of an essential character. . . . We appeal, therefore, on behalf of the Government to every employer who is finding his business threatened with diminished productivity through the loss of men, not to accept such diminution as an inevitable consequence of the war, but to make every possible effort to maintain his production by using women, whether in direct substitution for the men who have been withdrawn, or by some subdivision or rearrangement of his work."

The Home Office and the Board of Trade are prepared to give employers all the help in their power in taking this course, and a special Advisory Committee has been appointed to inquire into the subject.

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HIGH SPEED STEEL SCRAP.

Arrangements have been made by the Ministry of Munitions whereby the makers of High Speed Steel will take back all scrap, short ends, &c., at uniform prices, namely, 5d. per lb. for turnings; 6d. per lb. for bar ends, delivered steelmakers' works.

Such scrap should preferably be returned to the manufacturers who supplied the original steel, and should be free from all foreign substance, particularly other kinds of steel. According to the Defence of the Realm Regulations, it is illegal to dispose of High Speed Steel except through authorised channels, and users should, therefore, adopt the above arrangement in every case.

THE LIGHTING OF THE WOOLWORTH BUILDING, NEW YORK CITY.

In our February issue (p. 74), a reference was made to the large Woolworth building in New York, which is stated to be piped throughout for gas. We are informed, however, that this building, while piped for gas, is at present lighted both inside and outside by Mazda electric lamps, and we are reproducing a photograph kindly sent us by the National Lamp Works of Cleveland, Ohio, U.S.A., showing the appearance of the building by night.

The way in which the strongly illuminated tower "stands out" is most striking, and when the restoration of peace enables us in this country to turn our attention to decorative aspects of exterior lighting, this method of illuminating buildings by concealed lamps well deserves consideration. In this case the outside lighting is effected by six hundred 250-watt Mazda lamps in projectors, whose action can be clearly seen in the photograph.

This installation is interesting as an example of modern spectacular exterior lighting, and the photograph is certainly one of the best representations of such night-effects that have come before our notice.

REVIEWS OF BOOKS.*

Hygienic Conditions of Illumination in Workshops of the Women's Garment Industry, by J. W. Schereschewsky and D. H. Tuck. (United States Public Health Service Treasury Dept., Washington; Public Health Bulletin, No. 71, May 1915.)

This Bulletin, which forms one of the series on "Studies in Vocational Diseases," was issued in May, 1915. In view of the recent Report of the Home Office Committee on Factory Lighting in this country, it is gratifying to see that this subject has been studied very closely by the United States Public Health Service. The Bulletin contains two distinct sections, the first dealing generally with the health of garment workers, the second devoted entirely to lighting conditions in this trade. The investigations into the bodily condition of the workers, their habits, and the defects possibly engendered by their occupation are remarkably complete, and it is noteworthy that among the defects noted, the cases of defective vision formed 69 per cent., while 50 per cent. suffered from results of faulty posture (a condition which, as has been shown, may quite conceivably be accentuated or even produced by wrong shadow conditions and imperfect illumination).

The section on lighting occupies about 125 pages. Detailed tests of the illumination, diagrams showing the correct and incorrect positions of benches with regard to the light, and particulars of the reflectors suggested for artificial lighting, together with polar curves, are furnished. A complete photometric survey was made of 34 shops.

Among the practical suggestions for natural and artificial illumination, a working illumination of 5—7 foot-candles is recommended (partly on consideration of the report on school lighting presented by the Joint Committee of the Illuminating Engineering Society in London in 1914); due emphasis is placed on avoidance of glare and the use of light surroundings in workrooms. We hope to deal more fully with this report shortly. Meantime it is of interest to put on record a most valuable piece of work.

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The Excess Profits Duty and Profits of Controlled Establishments, by Spicer and Pegler, Chartered Accountants. (H. Foulks, Lynch and Co., 61, Watling Street, E.C. 1916. 6s. net.)

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* To some of these publications we hope to refer more fully shortly.

INDEX, April, 1916.

THE INDUSTRIAL OUTLOOK AND ITS RELATION TO THE BRITISH GAS INDUSTRY.

A striking address on the above subject was recently delivered by Mr. H. M. Thornton before the Society of British Gas Industries at their Eleventh Annual Meeting.

The lecturer spoke of the need for continual and combined national effort. "State aid for industry by means of an extension of the Commercial Branch of the Board of Trade, that is to say, industrial administration by business men on business lines; improved relations between Capital and Labour; a revision of our Educational System in the light of new requirements, and the establishment of schemes for industrial research as it is known in America," were among the many suggestions brought forward.

Special reference was made to the part played by the gas industry in aiding the production of munitions of war. Gas industries undertakings, Mr. Thornton remarked, were united in doing their utmost to promote the engineering and other conditions essential to the supply of cheap gas, which would be one of the most important considerations in coming years.

One factor of great importance in this connection is the development and sale of residual products, and gas undertakings are doing all they can by research to bring about progress in this respect.

Naturally, too, there are great opportunities in the direction of discovering new opportunities for the use of gas, and there are still many cases in which gas is being employed in the crudest manner possible, without efficiency and without economy. At the present time it is estimated that only 15 million tons of coal are used in the gas works of the United Kingdom, as compared with 100 million tons consumed (and their valuable residual products utterly lost); there are thus great opportunities for further development.

Mr. Thornton referred to the system of industrial research scholarships now in operation in the Universities of Pittsburg and Kansas, and recalled that the Society of British Gas Industries had been instrumental in founding the Livesey Chair at the Leeds University, which was already doing useful work.

Another question of great importance was the utilisation of mineral products in the Empire. Owing to past shortsightedness in this matter, the supplies of zinc and nickel, both invaluable for war-purposes, had been exploited on the Continent instead of being developed within the British possessions. Another instance was furnished by the deposits of monozite sand, essential for the manufacture of thorium nitrate for mantles, which, however, owing to the enterprise of the Foreign Office, was now fully at the disposal of this country.

Finally, an appeal was made for preserving the health of the worker. Proper housing conditions, cheap and speedy means of conveyance of employees to and from works or factory, and the provision of industrial canteens supplying meals at moderate prices are all matters which cannot be neglected if the workers' efficiency is to be maintained at its highest level, and the Ministry of Munitions have welcomed and encouraged all attempts that have been made in these directions.